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In the Matter of	)	
	)	
Inquiry Concerning the Deployment of	)	
Advanced Telecommunications	)	CC Docket No. 98-146
Capability to All Americans in a Reasonable	)	
and Timely Fashion, and Possible Steps	)	
To Accelerate Such Deployment	)	
Pursuant to Section 706 of the	)	
Telecommunications Act of 1996	)	

COMMENTS OF THE
WIRELESS INFORMATION NETWORKS FORUM

The Wireless Information Networks Forum ("WINForum") herewith submits its comments in response to the above-captioned Notice of Inquiry.[1] Given the enormous potential of unlicensed devices in meeting Congress' goal of delivering advanced telecommunications capabilities to the American public, WINForum is pleased to comment on this NOI. In this regard, WINForum notes below a few simple regulatory measures that could accelerate the deployment of such services using unlicensed technology.

I. INTRODUCTION

WINForum is a joint computer and communications industry technical forum to promote wireless information networking. Starting in the late 1980s, WINForum designed and worked

[1] Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion, and Possible Steps To Accelerate Such Deployment Pursuant to Section 706 of the Telecommunications Act of 1996, CC Docket No. 98-146 (Aug. 6, 1998) ("NOI"). Pursuant to an Public Notice, the deadline for comments was extended until September 14, 1998. *See FCC Public Notice*, DA 98-1624 (Aug. 12, 1998).

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with the Commission to implement the spectrum etiquette for 2 GHz Unlicensed PCS devices. This etiquette permits unlicensed devices in the 1910-1930 MHz UPCS band to operate on a cooperative basis, maximizing spectrum efficiency in information throughput while minimizing inter-device interference.

More recently, WINForum filed the initial petition for rulemaking leading to the establishment of the Unlicensed National Information Infrastructure ("UNII") band at 5 GHz. WINForum had requested that the FCC allocate 250 MHz of spectrum from 5.1 to 5.35 GHz, and retain in reserve the 5.35-5.45 GHz band for future development, to support bandwidth-intensive multimedia offerings on an unlicensed basis. Ultimately, the FCC allocated the 5.15-5.25 GHz band ("UNII Low Band"), the 5.25-5.35 GHz band ("UNII Mid Band"), and the 5.725-5.825 GHz band ("UNII High Band"). Each band is subject to different limitations on permitted power usage. WINForum is currently working with industry members and other organizations to ensure UNII devices would share the UNII spectrum efficiently and effectively by limiting interference between devices and maximizing the use of spectrum, while providing manufacturers with flexibility to create an innovative range of products for the American public.

As noted in the NOI, the purpose of Section 706 was to identify and remove barriers to the deployment of advanced services. As discussed below, unlicensed wireless devices are capable of providing the American people with a broad range of advanced telecommunications capabilities. If the Commission takes the regulatory actions described below, these unlicensed wireless services will continue to flourish and accelerate deployment of advanced resources for consumers, educators, businesses, and industrial users

II. UNLICENSED WIRELESS DEVICES CAN BRING ADVANCED SERVICES TO THE AMERICAN PUBLIC

Unlicensed systems are among the most valuable, most exciting, and most widely needed technologies today. Traditionally, unlicensed—or Part 15—technologies have occupied the lowest rung on the Commission's spectrum allocation ladder. These devices operated without interference protection from other users and under requirements to protect all licensed systems. Despite these handicaps, companies both large and small have used Part 15 allocations to develop a wide array of valuable and needed products. In response to industry and FCC initiatives to broaden the development of unlicensed technologies, the most recent unlicensed spectrum allocations have shifted from the traditional model and accorded unlicensed devices some protection from other users. This has allowed the industry to pursue other needed applications employing higher efficiency, broader band modulation techniques in a more predictable—and hence less commercially risky—environment.

Unlicensed systems already span a broad range of products. These products range from simple devices designed to address niche applications for specific users to handheld devices that harness the power of the National Information Infrastructure in simple, powerful packages. These products include advanced, interference-free extended range cordless telephones; wireless data collection and point-of-sale devices; untethered Personal Digital Assistants; and, complex campus-area and in-office PBX systems and wireless computer networks. What these devices share in common are:

- They are designed largely to address the everyday communications needs of American businesses, industries, and consumers by providing high levels of functionality in an extremely cost-effective manner, without airtime fees.
- They are designed to allow immediate, rapid deployment without the need for time-consuming licensing procedures; the construction of complex, carrier-provided

infrastructures; the deployment of expensive internal wiring and rewiring; or massive start-up investments.

- They can be deployed anywhere, whether in the home, in an office building, on a factory floor, in a school, and in rural and urban areas alike.
- They are highly efficient, sharing the radio spectrum as a common good and operating in a manner that minimizes potential interference and allows all devices equal access to the spectrum.
- They are provided by a host of manufacturers developing competing products with innovative new functionalities.

Thus, even today, these devices are reshaping the way that American businesses and consumers communicate by offering unparalleled flexibility and functionality at low cost.

These unlicensed products, however, are only the tip of the iceberg. The recent allocation at 5 GHz for the next generation of UNII devices will offer data transmission rates of at least 25 million bits per second—a data rate that is the minimum necessary to support information-rich multimedia applications. While the ability to transmit roughly one full page of text in one ten-thousandth of a second may seem fast, even with this quantum leap forward in speed, a 100 kilobyte color JPEG image will require over three one-hundredths of a second and a 40 megabyte high-resolution medical image will take over 10 seconds.

Recent experience has already revealed that both learning and human interaction are tangibly facilitated by the presentation of information in a manner that combines sound, graphical imagery, data, and video interchangeably. Accordingly, these high speed networks should be viewed as critical technologies allowing students at schools to connect to the full power of the Internet, permitting businesses to interconnect wirelessly with advanced landline network functionalities, and allowing industries, hospitals, and other institutions to apply advanced computing applications where they are needed, when they are needed.

To demonstrate the immense advanced potential of UNII devices, a few of the types of applications that have been discussed include:

- *Medical Applications.* Broadband wireless networking holds significant potential to improve the quality, and reduce the costs, of medical care in the United States by providing physicians with usable tools that offer clinical data at the point of care, improve reimbursement through better data collection, and eliminate or refine expensive and time consuming manual processes. For example, the efficiency of medical staff could be improved by giving them on the spot, real time access to patient data, including x-ray and MRI images, video recordings, medical charts, and other records and by enabling group diagnosis, resulting in better and more efficient diagnosis of complex cases without the need for the relevant experts to physically get together. Such offerings will also permit physicians to review digitally-transmitted X-rays, computer aided-tomography, full-motion ultra-sound imaging studies, and magnetic resonance imaging diagnostics while at the patient's bedside. Due to the transitory nature of patients while in a hospital and the continual reshuffling of patients through various departments, wireless connectivity may again be the only sufficiently flexible solution for giving physicians, medical staff, and patients access to needed multimedia applications.

- *Educational Uses.* Many educational institutions in the United States are, unfortunately, characterized by an outdated physical plant in conjunction with a lack of financial resources. Since the cost of physically wiring a network tap to every child's desktop is phenonmenal, a wireless broadband network is potentially the only means of multimedia data dissemination within a classroom and perhaps the only economically feasible means of providing students with at-the-desk access to not only the school library, but also a multimedia array of services available on the Internet. The importance of the last link to the student cannot be understated. Even though thirty to fifty percent of America's *schools* have access to the Internet, only two to five percent of America's *classrooms* have such access. Notably, providing cost-effective access to the Internet for educational institutions also has the beneficial effect of equalizing the resources available to students whether they attend well-funded private schools or one-room schoolhouses in rural America.

- *Libraries and Information Uses.* Wireless networks have the potential to significantly improve the delivery of services by, and the functioning of, libraries. Libraries are currently digitizing collections for delivery to local, national, and even global audiences; providing public terminals that enable individuals to connect to the Internet; creating on-line collections of hundreds of thousands of pieces of sheet music; and creating electronic card catalogs that index both the library's own materials and material on the Internet. However, library funding is being slashed and, with the high costs of cabling buildings, low cost wireless systems may be the only answer if libraries are to thrive as key resources on the Internet and as public on-ramps to the Information Superhighway.

- *Business and Industrial Applications.* Finally, broadband networks will create jobs, foster economic growth, and improve access to communications by industry and the American public. In order to compete successfully domestically and in global markets, business and industry must be flexible, responsive, and highly efficient. Increasingly, businesses and industries have turned to wireless solutions to achieve these goals, which invariably involves pushing greater data gathering and processing capabilities downstream closer to the customer or the process at the core of the enterprise. These kinds of applications demand the flexibility offered by wireless solutions in conjunction with the speed and work-saving ability of the most advanced multimedia technologies. Indeed, WINForum believes that these entities may be the earliest adopters of this new technology, which provides a substantial manufacturing base to distribute development costs and reduce costs for all other institutions

The systems and applications described herein do not define the entire potential of unlicensed systems. There are many yet-to-be-defined applications that can benefit from the availability of readily accessible unlicensed spectrum. Indeed, precisely because these systems are lightly regulated and allow any type of application or system that conforms to broad sharing requirements, these types of allocations provide an ideal home for small companies and entrepreneurs to innovate and create the next "killer app" in communications. Making these types of allocations available, without regulatory constraints, will allow the industry to create freely, providing an environment much like the personal computer industry of the late 1980s.

III. IN ORDER TO FULFILL THE PROMISE OF UNLICENSED DEVICES, THE COMMISSION SHOULD TAKE A NUMBER OF STEPS REGARDING SPECTRUM ALLOCATIONS AND SERVICE RULES

A. The Commission Should Adopt a Forward-Looking Approach to Spectrum Allocations for Unlicensed Devices

More spectrum will continue to be necessary in the future for third- and fourth-generation unlicensed technologies. The Commission should plan for the development of 100 Mbps and higher technologies by considering reservations of spectrum for these purposes. The reservation of spectrum in higher bands earlier, rather than later, can assist in the acceleration of products to the public in a myriad of ways. First, having reserved spectrum permits manufacturers to focus research efforts on specific spectrum targets, decreasing development cycles. Forward-looking spectrum policies also permit standards organizations to proceed on parallel efforts, centralizing around specific service definitions and application targets, as well as promoting interoperability and the ability to integrate easily wireless products with ongoing landline and fiber optic developments. Finally, allocating spectrum early will focus global efforts on identified spectrum bands, promoting international cooperation and providing larger markets for unlicensed products. This, in turn, can lead to manufacturing efficiencies and lower product prices.

The Commission's spectrum allocation policies, for existing allocations and for future unlicensed allocations, should also consider the synergistic impacts of locating unlicensed device allocations proximate to licensed service bands. As shown by the UPCS band, locating unlicensed product bands near licensed services facilitates interoperability and expands the range of services available to the public. Indeed, the Commission may wish to consider the benefits of allocating spectrum for licensed operations in the 5 GHz band adjacent to the UNII allocations.

B. The Commission Should Ensure Sufficient Capacity Is Available at 5 GHz To Meet Demand for Multimedia Wireless Applications

As documented in it its petition for rulemaking to establish the UNII band, WINForum's demand estimates have shown that 350 MHz is the minimum amount spectrum that is necessary to support UNII applications. While WINForum commends the Commission for allocating three 100 MHz bands at 5 GHz for unlicensed use, certain restrictions on these bands, and the other users in the bands, adversely impact the capacity that can be served by this allocation. The 300 MHz allocated, thus, falls far short of the 350 MHz that will ultimately be required if advanced unlicensed services are to meet their potential.

For example, the presence of existing users in the 5.725-5.825 GHz band severely constrains the ability of UNII devices to meet multimedia demand in the high band. This band, in fact, was not part of the original WINForum UNII petition, largely because the band was already in substantial use by Part 15 spread spectrum devices. That being said, however, the flexibility to use the band in a compatible manner under more flexible rules overall is nonetheless beneficial and the allocation for UNII devices in the high band is in the public interest. WINForum's demand estimates, however, assumed largely unoccupied spectrum, and thus the 100 MHz available at 5.725-5.825 GHz should not be considered as offsetting, to any substantive degree, the 350 MHz ultimately needed for broadband unlicensed operations. Under the circumstances, the Commission should also allocate, or reserve, at least an additional 100 MHz of spectrum in the 5 GHz range to meet demand for advanced applications.

Similarly, the stringent power and operational limits on the spectrum in the 5.15-5.25 GHz band also affect the available capacity to meet demand identified by WINForum. Because of interference concerns expressed by satellite operators, devices operating in the UNII Low Band are limited to inside-only operation and may only transmit with restricted power. As discussed in the attached technical appendix, however, these restrictions appear unjustified as an engineering matter, and WINForum believes the Commission should adopt rules permitting the use of the UNII Low Band fully comparable to the UNII Mid Band.

C. The Commission Should Allocate Additional Isochronous Spectrum at 1.9 GHz for UPCS devices

In the Commission's original PCS allocation order, the FCC found that a total of 40 MHz of spectrum was needed for unlicensed PCS devices. Accordingly, the order allocated the band from 1900-1940 MHz for UPCS, with 20 MHz allotted for asynchronous devices and 20 MHz allotted for isochronous devices. Upon reconsideration, however, the Commission halved the size of the UPCS allocation to ensure the availability of sufficient spectrum for licensed uses, trimming the UPCS band down to 1910-1930 MHz. At that time, the Commission indicated that it would "initiate a proceeding to consider allocation of additional spectrum to meet long term spectrum requirements for unlicensed PCS devices."[2]

Since the Commission's PCS reconsideration order, it has, in fact, allocated additional asynchronous spectrum. In 1995, the Commission allocated the 2390-2400 MHz band for such devices, restoring the full 20 MHz originally made available for asynchronous devices. The Commission has not yet, however, allocated additional isochronous UPCS spectrum. WINForum is developing a specific proposal to address the future spectrum needs of iscochronous UPCS devices.

D. The FCC Should Continue to Work With Industry to Flexibly Regulate Unlicensed Services

As noted above, unlicensed devices are rapidly evolving in response to technological advancements and changes in consumer demand. Rapid changes in the types of equipment offered necessitates a flexible regulatory regime. Recognizing this fact, the Commission has engaged in flexible regulation and has been receptive to industry when clarification or rule modifications appeared necessary or advisable. WINForum applauds the Commission for working in partnership with industry in this manner, and urges the Commission to continue its efforts to maintain a strong working relationship with unlicensed device manufacturers. Only in

[2] PCS Order at ¶207.

this manner can industry meet the challenges of future technological innovation and accelerate the development of products bringing advanced services to the American public.

IV. CONCLUSION

WINForum commends the Commission for initiating this inquiry to ensure that consumers and businesses have access to the most advanced telecommunications offerings. As discussed above, unlicensed products are an important component in satisfying these needs, and unlicensed products will continue to develop new and important telecommunications capabilities. By taking the regulatory actions noted above, WINForum believes that the Commission will ensure that unlicensed devices realize their full potential and that the United States continues to be a world leader in advanced telecommunications services.

Respectfully submitted,

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SHARING BETWEEN U-NII DEVICES AND THE MOBILE SATELLITE SERVICE

A1. Introduction and Summary

Mobile Satellite Service (MSS) system feeder uplinks use spectrum in the lower U-NII band (5150 to 5250 MHz). WINForum studied the question of U-NII/MSS feeder link sharing before filing the original 5 GHz petition and did more extensive analysis during the allocation process.

There are two MSS systems which use the lower U-NII band in the feeder links. The GLOBALSTAR™ System uses multiple polar orbit satellites at an orbital altitude of 1414 kilometers and the ICO MSS System uses fewer satellites at a higher orbit of 10,355 kilometers.

Reference 1, was filed with the original WINForum petition for the U-NII allocation. It contains an analysis of the effects of unlicensed 5 GHz wireless systems on Low Earth Orbit (LEO-48, GLOBALSTAR™) and Medium Earth Orbit (ICO-12) MSS systems as well as the effect of these MSS systems on the unlicensed wireless systems. The analysis of the GLOBALSTAR™ system was updated extensively by WINForum during the 5 GHz unlicensed petition process. References 2 through 7 reflect this and are used and updated below. There have been further studies of the parameters affecting the influence of unlicensed 5 GHz devices on both the ICO and the Globalstar systems. This appendix summarizes the WINForum studies and updates them with the newer parameters.

The first section of this appendix presents the parameters of unlicensed wireless systems which affect their influence on the feeder links, and later sections apply the parameters to the two MSS systems of concern.

Table A1 summarizes the results in terms of the number of U-NII devices required to create a minimal effect on the MSS feeder uplinks. The 1% duty cycle of the table is the upper limit

	Globalstar System, At U-NII Duty Cycle = 1%		ICO System, At U-NII Duty Cycle = 1%	
Outside/Inside Ratio (%)	Baseline Excess Attenuation	Baseline Excess Attenuation - 4 dB	Baseline Excess Attenuation	Baseline Excess Attenuation - 4 dB
1%	27,700	11,030	5,510	2,190
5%	16,000	8,930	3,180	1,775
10%	8,740	7,210	1,740	1,430
20%	4,580	4,330	910	860

Table A1. Necessary Number of U-NII Devices (in Millions) to Affect MSS Feeder Uplinks

This is the number of U-NII devices necessary to reduce the capacity by 1% for Globalstar™ or to create an interference level within 15 dB of thermal noise at the ICO satellite.

expected for U-NII devices and the baseline excess attenuation is an update of that used in prior reports. It is the best information now available for both outside clutter attenuation and building attenuation. The lower excess attenuation of the table is a lower limit of the current estimates. The proportion of active devices that are deployed outside is unlikely to exceed 5% even if the lower band inside only restriction is lifted. Nevertheless, the table shows the result with outside inside ratios up to 20 %.

In all cases shown, the necessary number of devices exceeds the population of North America.

A2. Factors Affecting U-NII to MSS Emission Levels

U-NII devices are very low power devices; individual device power levels are insignificant with respect to the power generated by the MSS feeder uplink systems. Only if many U-NII devices transmit simultaneously might there be any conceivable effect on the feeder links. For this reason the peak power of U-NII devices is of little concern. The required numbers are so large that the average power is the parameter of concern.

Further, because of the averaging effect, antenna gain is not a factor. Thus, the power limits only need to be specified in terms of the power delivered to the antenna; not in terms of the equivalent isotropic power. The effect of antenna gain on the Globalstar™ system was extensively studied by WINForum and is documented in references 3 and 4. These documents show that the worst case systematic antenna pointing arrangement for unlicensed devices almost always results in less interference. At the most sensitive and highly unlikely antenna directivity conditions, the interference effect is less than 1 dB.

Thus, this section concentrates on evaluating the average power density resulting from the power actually delivered to the unlicensed device antennas.

<u>Composite Power Spectral Density and Bandwidth</u>

The level of U-NII power in the vicinity of an MSS satellite feeder uplink receiver depends on the composite power generated by a large number of devices reduced by the path attenuation between the devices and the satellite. The composite power density is the product of the number of devices with RF power on within range of the MSS receiver and the power spectral density per device.

The power spectral density of U-NII middle band devices in the US is limited by two stipulations in the regulations; the total power in the 26 dB emission bandwidth (B) and the maximum permitted power spectral density within the bandwidth B. If the emission bandwidth is less than 20 MHz, the power level limit is proportional to the bandwidth with a peak value of 12.5 mw/MHz. If the emission bandwidth is greater than 20 MHz, the power level limit is fixed at 250 milliwatts.

> From the rules: *The power level limit is 11 dBm + 10LogB or 250 milliwatts (24 dBm) whichever is less and the maximum power spectral density is 11 dBm per 1 MHz.*

If the low power and indoor operation restrictions in the lower band are eliminated, U-NII devices can be expected to be spread evenly in frequency over the full 300 MHz of spectrum. The bandwidth of U-NII devices will be greater than that of the MSS uplink channels. Thus, the actual number of active U-NII devices can be expected to be 300 MHz/B times the number of active devices on any one MSS channel.

As a consequence of the above, the composite power spectral density generated by a number (N_t) of U-NII devices is proportional to the average bandwidth for those U-NII devices with a bandwidth less than 20 MHz and is independent of the average bandwidth for those devices with a bandwidth greater than 20 MHz.

Let:

p_{sdc} = the composite power spectral density in mw/MHz;

B = the 26 dB emission bandwidth in MHz:

d = the average active/inactive ratio (duty cycle):

N_c = the number of devices on an MSS channel in range of the satellite;

N_t = the total umber of devices within the 300 MHz allocation in range of the satellite;

α_1 = the average ratio of device power spectral density to allowable power spectral density; and

α_2 = the average ratio of power spectral density across the emission bandwidth to peak power spectral density.

Then, with B_m the mean emission bandwidth and a peak power spectral density per device of 12.5 mw/MHz:

$p_{sdc} = 12.5\alpha_1\alpha_2\, dN_c = 12.5\alpha_1\alpha_2\, dN_t(B_m/300) = 4.167\text{x}10^{-2}\alpha_1\alpha_2\, dN_t B_m$ for all B < 20 MHz.

$p_{sdc} = 12.5\alpha_1\alpha_2\, dN_c\,(20/B_m) = 12.5\alpha_1\alpha_2\, dN_t(1/15) = .833\alpha_1\alpha_2\, dN_t$ for all B>= 20 MHz.

The ratios α_1 and α_2 determine the average power spectral density per device. The average power spectral density is the parameter of concern because the composite power is generated from a very large number of devices and such large numbers will not have common spectrum peaks in any MSS band. In fact, the center frequencies are very likely to have little commonality.

A conservatively high value for the achievable $\alpha_1\alpha_2$ product is 0.5. The output power of U-NII devices can be expected to be less than the allowable value because of both variance in power output and power spectrum ripple within the pass band. Thus, α_1 will be less than 1. The maximum power spectral density (11 dBm/MHz) leads to the full permissible power only if the emission spectrum is rectangular. Thus, the average power spectral density over the 26 MHz emission bandwidth will be less than the maximum and α_2 will be less than 1.

As demonstrated, the composite generated power spectral density is maximum for a given number of U-NII devices if the U-NII device emission bandwidth is 20 MHz or higher. The composite power spectral density will be less than $0.833\alpha_1\alpha_2\, dN_t$ in accordance with the incidence of devices with emission bandwidths greater than 20 MHz and will be lower for those devices with emission bandwidths less than 20 MHz. If it is assumed that all U-NII emission bandwidths are 20 MHz or greater then

$p_{sdc} <= 0.42dN_t$ mw/MHz with $\alpha_1\alpha_2 = 0.5$.

The upper limit is $0.833dN_t$ mw/MHz which would be the case if all bandwidths are 20 MHz or greater and $\alpha_1\alpha_2 = 1$.

A conservatively high assumption is that ½ or more of devices will have emission bandwidths less than 20 MHz and that the half with bandwidths below 20 MHz will average 10 MHz. This would lead to a conservative assumption that

$p_{sdc} <= 0.31dN_t$ mw/MHz with $\alpha_1\alpha_2 = 0.5$. Eq. A2-1

This is about 1.3 dB lower than the assumption that all bandwidths are greater than 20 MHz.

Active/Inactive Duty Cycle Ratio

The composite power spectral density of a U-NII devices is very dependent on the active/inactive ratio (hereinafter duty cycle) of U-NII devices.

WINForum based the spectrum needs estimates for U-NII on the duty cycle per user in the busiest U-NII device clusters. The spectrum needs estimate is given in Reference 6. The following multi-media spectrum requirements per user are from this reference.

This estimate assumes the presence of LAN access points (or base stations) which serve multiple mobile devices and thus individually have higher duty cycles; it is the estimate of the spectrum demand per user including that stimulated at the access point.

Type of Information	Spectrum Needs Per User
Video	300 kHz
Data	156 kHz
Voice	40 kHz
Total	496 kHz

Table A2-1. Spectrum Needs per User
Busiest Locations
From the U-NII Petition

The total of 496 kHz is 2.48% of a 20 MHz U-NII channel and is less for higher bandwidth channels. Thus, if the assumption is made for the previous section that all bandwidths are greater than 20 MHz, the resultant duty cycle is less than 2.48%. If the bandwidth is less, then more devices will be required to generate a given composite power spectral density and the effect balances out.

The estimated spectrum in the WINForum petition based on these assumptions was 200 to 300 MHz to serve the voice, LAN and multi-media needs. *The spectrum request was based on this peak duty cycle*; there is no reason to believe that WINForum would *understate* the duty cycle as this would lead to a lower spectrum needs estimate. Thus, the estimate is truly the very upper limit of the average duty cycle of transmissions created or stimulated by individual unlicensed devices.

Further, the estimate is based on the average activity level of the busiest regions in an area about the size of a building floor at the peak activity times. Most locations will have activity levels much lower than this and indeed, many U-NII devices will have their power switch off and be totally inactive even in the busiest times. A 1% duty cycle for U-NII devices serving the wireless access needs for voice, data and multi-media is conservative; that is, the actual duty cycle will be lower.

There has been concern within the US that not all applications will be for this voice, data and multi-media application and that the duty cycle may be much higher in these other cases. However, there are other means of controlling these other applications without severely limiting the prime application for which the 5 GHz band was originally requested in the WINForum petition. An approach pursued by Apple/WINForum is described in Reference 2.

The IEEE 802 committee is now adding a 5 GHz PHY to its wireless LAN standard. This standard is intended to serve data communication needs. Devices conforming to this standard will have duty cycles consistent with the data communication demand alone. Thus, devices following this standard will have duty cycles below 1% even in the highest activity clusters. The inside - low power restriction applies to these devices in the US nevertheless.

Excess Path Loss

The free space path loss of an U-NII device emissions at the satellite is given by

$$\text{Path Loss} = 20\,Log\left[\frac{4\pi D}{\lambda}\right]$$

where λ is the wavelength and D is the distance from the device to the satellite.

The path loss exceeds this free space value if the devices are inside buildings or if they are outside in a relatively cluttered environment such as the typical urban and suburban landscapes. The values of excess attenuation are under study by the international community now. The following is a review of values that are sufficiently accurate for current discussion.

First, it is noted that a correction is needed to the normally quoted average excess attenuation. Excess attenuation, in deciBel units obeys a near Normal probability distribution (Log Normal distribution) in virtually all cases. The actual mean loss in deciBels for a large number of sources for which the attenuation follows a Log-Normal distribution differs from the mean of the distribution. Expressed mathematically

$$\text{Mean Loss in dB} = -10\text{Log}\left[\text{Mean of}\left(10^{-A/10}\right)\right]$$

Where A is the random variable equal to the path loss expressed as a deciBel quantity. The mean attenuation is less than the mean of A and depends on the standard deviation of the distribution of A. Simulations were run to correct for this and the results are shown in table A2-3.[3]

[3] The simulation used a truncated Log-Normal distribution. All simulated values less than 0 dB were converted to 0 dB and the linearized mean of the truncated distribution was used.

Vogel and Torrence (reference 9) reported measurements made in a number of typical buildings. AirTouch, in their reply comments to the FCC U-NII Notice of Proposed Rulemaking (reference 7), quoted these studies and presented a probability distribution of in-building loss derived from them. The mean loss (mean value of A) was 17 dB and the distribution was near Log-Normal with a standard deviation of about 10 dB. Simulations showed the actual mean loss of a large number of paths for this distribution to be 8.6 dB as shown in table A2-2 below. These measurements will be taken as typical for purposes here.

The structures in the Vogel report were illuminated in a line of sight into an opening such as a window or glass door. Slant angles varied from 18 degrees to 47 degrees. Multiple measurements were made in a line from well inside the building to the point of illumination near the window or door. In general, the attenuation was very high to and from points within the building (20 to 25 dB) and very low (order of 5 dB) near the illuminated opening.

The Vogel and Torrence measurements will be taken as the values for buildings at low slant angles.

The attenuation from and to inside building points indicates that the attenuation at higher slant angles is higher.

Measurements reported by Hata (reference 10) indicate that the attenuation due to obstruction losses outside in a suburban environment have a Log Normal mean of about 8 dB at low slant angles.[4] Losses are much higher in an urban environment and lower in open environments.

[4] The Hata study was at a lower frequency and projected to be accurate to 1.5 GHz. Other measurements indicate that the frequency projections to 5 GHz are nevertheless quite accurate.

	DeciBel Mean	DeciBel StDev	Simulated actual mean in dB
Building loss at low slant angles	17	10	8.6
Outside loss at low slant angles	8	4	6.3
Composite inside loss at low slant angle			**14.9**

Table A2-2. Result of Simulation to Determine Excess Building Loss at Low Slant Angle

Table A2-2 shows the result of the simulations and the resulting building loss at low slant angles.

Table A2-3 below based on the above considerations shows a list of the baseline values of excess attenuation The values are the best estimate that can be made now. However, the inside loss of table A2-3 is based on a small sample of buildings and the outside clutter loss is based on some frequency and environment projections. Thus, the last column was added to determine the sensitivity of the of the analysis to possible overestimates.

	Predicted actual mean in dB	Predicted actual mean minus 4 dB
Composite inside loss at low slant angle	**14.9**	**10.9**
Inside loss at high slant angle	**20**	**16**
Outside loss at low slant angle	**6.3**	**2.3**
Outside loss at high slant angle	**0**	**0**

Table A2-3. Mean Excess Loss in Inside and Outside Deployment

The FCC rules require that *all* U-NII devices in the lower band be inside buildings. There would be little effect if this rule were relaxed. Currently, virtually all wireless LAN devices are deployed inside buildings. It can be expected that this will continue to be the case. The outside/inside ratio will likely remain well below 1% even if the inside only restriction is relaxed. However, the mean loss for higher ratios is presented for comparison. The following table gives values of the composite mean excess loss with various inside/outside ratios using the attenuation values above.

	Low Slant Angle	High Slant Angle
L_i	14.9 dB	20 dB
L_o	6.3 dB	0 dB
Outside/Inside Ratio (F_o)		
1 %	14.6 dB	17.0 dB
5 %	13.7 dB	12.2 dB
10 %	12.8 dB	9.6 dB

Table A2-4. Mean U-NII Excess Attenuation at High and Low Slant Angles Using the Baseline Excess Attenuation.

Table A2-4 values were calculated using the following

Let:

F_o = the outside/inside ratio as a fraction;

L_i = the mean excess attenuation for inside devices;

L_o = the mean excess attenuation for outside devices; and

L_m = the mean excess attenuation.

The mean excess attenuation for a mix of inside and outside devices is given by

$$L_m = -10 Log\left[F_o x 10^{-Lo/10} + (1 - F_o) x 10^{-Li/10} \right].$$

Outside/Inside Ratio	Minimum of expected Attenuation (dB)	Minimum of expected attenuation less 4 dB
1%	14.9	10.9
5%	12.2	9.7
10%	9.6	8.8

Table A2-5. Composite Excess Attenuation Versus Outside/Inside Ratio Using the Lower of the Low and High Slant Angle Values.

Summary of Parameters

Parameter	Nominal	Extreme
Composite power spectral density	$0.31 N_t d$ mw/MHz	$0.42 N_t d$ mw/MHz
Duty cycle	< 1%	2.5 %
Low angle, inside excess attenuation	14.9 dB	10.9 dB
High angle, inside excess attenuation	20 dB	16 dB
Low angle, outside excess attenuation	6.3 dB	2.3 dB
High angle, outside excess attenuation	0 dB	0 dB

Table A2-6. Summary of Parameters

A3. Globalstar™ System

The Globalstar™ MSS System uses multiple polar orbit satellites at an orbital altitude of 1414 kilometers. The 5 GHz uplink frequency is translated to another frequency at the satellite and relayed to mobile units at the earth surface.

The Appendix to the AirTouch reply comments to the US FCC Notice of Proposed Rule Making in ET Docket 96-102 (U-NII) provides a formula for the capacity reduction that would result to the Globalstar™ system from unlicensed devices that share spectrum with the feeder uplink. That formula is:

$$\Delta C = \frac{10^{I_t/10}}{10^{I_{p15}/10} + 10^{I_t/10}},$$

where ΔC is the ratio of the Globalstar™ capacity with unlicensed 5.2 GHz devices to that without them, $I_t = -202.86\,\mathrm{dBW/Hz}$ is the total interference plus noise at the Globalstar™ subscriber unit excluding that from unlicensed 5.2 GHz devices, and I_{p15} is the aggregate power density from the unlicensed 5.2 GHz devices (Part 15 of the US CFR), in dBW/Hz.

Reference 2 uses this formula to demonstrate the effect of U-NII devices on the Globalstar™ capacity using a set of parameters which was under discussion at the time of the filing of reference 2. The AirTouch comments and reference 2 assume a round trip path loss exclusive of excess attenuation of 193.9 dB. Reference 2 also shows that there will be an additional effective loss of 2 dB in unlicensed device power level due to polarization losses and an additional increase of at least 1.6 dB due to the noise figure of the mobile handset. Using these and the parameters of section A2 with $p_{sdc} = 0.31dNt$.

$$i_{p15} = 1.05x10^{-3} dN_m 10^{-L_m/10} i_t$$

where $N_m = 10^6 N_t$ as used in reference 2, L_m is the composite mean excess path loss from table A2-4 $i_{p15} = 10^{I_{p15}/10}$ and $i_t = 10^{I_t/10}$. This leads to a capacity decrease of $\Delta_{\%}$ in the form of equation 7 of reference 2.

$$\Delta_{\%} < 0.105x10^{-L_m/10} dN_M \qquad \text{Eq. A3-1}$$

The satellite receiver uses an "iso-flux" antenna which has approximately equal gain at angles from the vertical to approximately 55 degrees from vertical. With this antenna pattern, at some satellite positions the receiver is in range of the majority of the US-Canada population. At such position, most of the concentrated population regions are at a low slant angle to the satellite. Thus, the low slant angle values of excess attenuation of table A2-4 are appropriate for computing the highest interference potential in these cases.

On the other hand, the dense population regions of North America are near each coast and when the satellite is directly over one region of dense population it is out of range of the other. Thus, there are also satellite positions at which the high slant angle values of excess attenuation is appropriate although not all of the densely populated regions of the continent will be in range at these locations.

Nevertheless, the lower value of attenuation will be used in all cases including the case where the

Outside/Inside Ratio	Minimum of expected Attenuation (dB)	Minimum of expected attenuation less 4 dB
1%	14.9	10.9
5%	12.2	9.7
10%	9.6	8.8

satellite is directly over one of the densely populated regions. That is, from table A2-5:

Table A3 gives the result of evaluating equation A3-1 for some typical to extreme parameters. It gives the number (N_M) of U-NII devices necessary to create a 1% effect on Globalstar™ capacity. These numbers exceed the population of North America by significant factors even with extreme parameter values.

If the number U-NII devices approach a value equal to the population, this in itself will verify the wisdom of permitting the devices to operate.

The table also shows that the effect of permitting outdoor operation is not significant. It is unlikely that outdoor operation will exceed 5% even if totally unconstrained. The table shows that even 20 % outdoor operation creates negligible interference.

Outside/Inside Ratio (%)	Baseline Excess Attenuation Duty Cycle 1%	Duty Cycle 2.5%	Baseline Excess Attenuation Less 4 dB Duty Cycle 1%	Duty Cycle 2.5%
1%	27,700	11,080	11,030	4,410
5%	16,000	6,400	8,930	3,570
10%	8,740	3,500	7,210	2,890
20%	4,580	1,830	4,330	1,730

Table A3: Number of U-NII Devices Necessary to Reduce the Globalstar™ Capacity by 1% (in Millions)

A4. The ICO System

The ICO MSS System uses fewer satellites at a higher orbital elevation of 10,355 kilometers. The antenna gain of the satellite receiver is 15 dB at mid beam and the 3 dB beamwidth approximately spans the earth diameter.

Information on the ICO system necessary to provide a specific analysis of the effect of unlicensed systems has not been made available. Thus, the analysis provided here must concentrate on the general effect that such operation has on an MSS system in which the uplink is the most sensitive component to interference and in which the only other interference is fundamental thermal noise. Such a system is most sensitive to U-NII interference. It is thus expected that the actual ICO system will be less sensitive to unlicensed operation.

The U-NII effect on the ICO feeder uplink is evaluated by computing the interference power density at the satellite relative to earth thermal noise. This overstates the relative effect of the unlicensed devices because the interference without unlicensed device noise will actually exceed the earth thermal level.

With i_{p15} the power density at the satellite receiver from unlicensed devices and i_t the earth temperature thermal noise density at the satellite, if $\frac{i_{p15}}{i_t} < 3.16x10^{-2}$ then the unlicensed device power density will be at least 15 dB below the power density from earth thermal noise at the satellite. Using the composite power spectral density of section A3 and again letting L_m be the excess loss, the following will assure at least the 15 dB margin

$$N_m < \frac{1.9}{d} x10^{L_m/10} \qquad \text{Eq A4-1}$$

At the high orbit of the ICO satellite, it is possible to have all of the US and Canadian unlicensed devices to be at a low slant angle relative to the satellite sometimes and at a high slant angle at other times. Thus, as for Globalstar™, the lower value for excess attenuation will be taken from Table A2-5.

Table A4 shows the result of evaluating equation A4-1. It gives the number (N_M) of U-NII devices necessary to create a power density at the ICO satellite within 15 dB of thermal noise. These numbers also exceed the population of North America.

The maximum effect that this power density level could have on ICO capacity is about 3%. It is unlikely that the actual effect level will be as high as 1%. ICO has not been forthcoming in providing actual system operation and only this fundamental limit can be given.

	Baseline Excess Attenuation		Baseline Excess Attenuation Less 4 dB	
Outside/Inside Ratio (%)	Duty Cycle 1%	Duty Cycle 2.5%	Duty Cycle 1%	Duty Cycle 2.5%
1%	5,510	2,200	2,190	879
5%	3,180	1,270	1,780	710
10%	1,740	695	1,430	574
20%	910	364	860	344

Table A4. Number of U-NII Devices Necessary to Create an Interference Level at the ICO Satellite within 15 dB of Thermal Noise (in Millions)

ICO has not made sufficient information available to assess the capacity effect of this noise level. The fundamental maximum effect is about 3%.

As was the case for Globalstar™, the table also shows that the effect on the ICO system of permitting outdoor operation is not significant.

A5. Conclusion

It has been shown that even with an average active/inactive power on/off ratio across the continent equivalent to the estimates used by WINForum for the most active small locations to justify the U-NII spectrum requests and with other parameters affecting performance estimated at values which would produce conservatively high power density values, the number of such devices required to have an effect on the MSS systems in the 5.15 to 5.25 lower 5 GHz band is much greater than will ever be achieved.

Thus, the power level in the lower band should be permitted to be as high as in the middle band and the inside-only restriction should be lifted.

References

Note: The 5.2 GHz unlicensed band has undergone the following sequence of names in the US, earliest to latest: High Speed Wireless Data Systems (HSWDS), Shared Unlicensed PERsonal Network (SUPERNet) and Unlicensed National Information Infrastructure (U-NII).

1. Annex to AT&T input to the IAC concerning WARC 97: Sharing Studies Concerning MSS feeder Uplinks and 25 Mb/s High Speed Wireless Data Systems (HSWDS). Attachment to the WINForum Petition. *Revised December 1994.*
2. Interference From U-NII Devices to the Mobile Satellite Service in the 5150-5250 MHz Band: Summary and Update. Update of Reference 3. *April 11, 1997.*
3. Effect of NII/SUPERnet Device Deployment on GLOBALSTAR™ Capacity. Attachment to the Apple/WINForum *ex parte* Meeting Report to the FCC OET, *December 11, 1996.*
4. Average Antenna Gain of Part 15 Devices as Seen by a Low Earth Orbit Satellite. Jay E. Padgett. Attachment to Apple/WIN Forum Ex-Parte Meeting Report, *December 6, 1996.*
5. Average Antenna Gain for NII/SUPERNet Devices. Donald C. Johnson. Attachment to Apple/WIN Forum Ex-Parte Meeting Report. *December 6, 1996.*
6. Appendix A to the WINForum SUPERNet petition: Spectrum Requirements Analysis, *May 15, 1995.*
7. Appendix to the AirTouch Reply comments to the US FCC Notice of Proposed Rule Making ("NPRM") in ET Docket 96-102. Technical Analysis Regarding Interference to MSS Links by Part 15 Devices Using 5.15-5.25 GHz Frequency Band [*sic*]. *August 14, 1996.*
8. Attachment to AirTouch FCC *ex parte* letter. Two sets of curves showing the percent U.S. capacity reduction for Globalstar™ vs. the number of unlicensed devices deployed in the 5150-5250 MHz band only. Filed *December 2, 1996.*
9. Slant-Path Building Penetration Measurements From 500 to 3000 MHz. Wolfhard J. Vogel and Geoffrey W. Torrence, Electrical Engineering Research Laboratory, University of Texas at Austin. Final Report on JPL Contract 956520. *October 30, 1995.*
10. IEEE Transactions on Vehicular Technology, Vol VT-29, No. 3, August 1980, "Empirical Formula for Propagation Loss in Land Mobile Radio Services," Masaharu Hata.